Google Earth Engine Evapotranspiration Flux --- EEFlux

Ayse Kilic, University of Nebraska-Lincoln

Rick Allen, University of Idaho

Justin Huntington, Desert Research Institute

Members of the Landsat Science Team

Doruk Ozturk, University of Nebraska-Lincoln

International Workshop on Evapotranspiration Mapping– Sept. 15, 2015

EEFlux-Development Team

An Evapotranspiration Modeling Tool on Google Earth Engine

Ayse Kilic – University of Nebraska -- Professor, *Member Landsat Science Team*
Justin Huntington – Desert Research Institute – Professor, *Member Landsat Science Team*
Rick Allen -- University of Idaho – Professor, *Member Landsat Science Team*

Doruk Ozturk– University of Nebraska – Developer
Baburao Kamble – University of Nebraska – Developer
Charles Morton – Desert Research Institute – Developer
Ian Ratcliffe – University of Nebraska – Remote Sensing Analyst/Developer

Clarence Robison – Univ. Idaho – GIS technician
Ricardo Trezza – University of Idaho – Professor
David Thau, Google, Inc. – Earth Engine Advocate
Tyler Erickson, Google, Inc. – Earth Engine Advocate
Noel Gorelick, Google, Inc. – Earth Engine Advocate
Rebecca Moore, Google, Inc. – Manager, Earth Engine / *Visionary*

WHAT IS EEFlux?

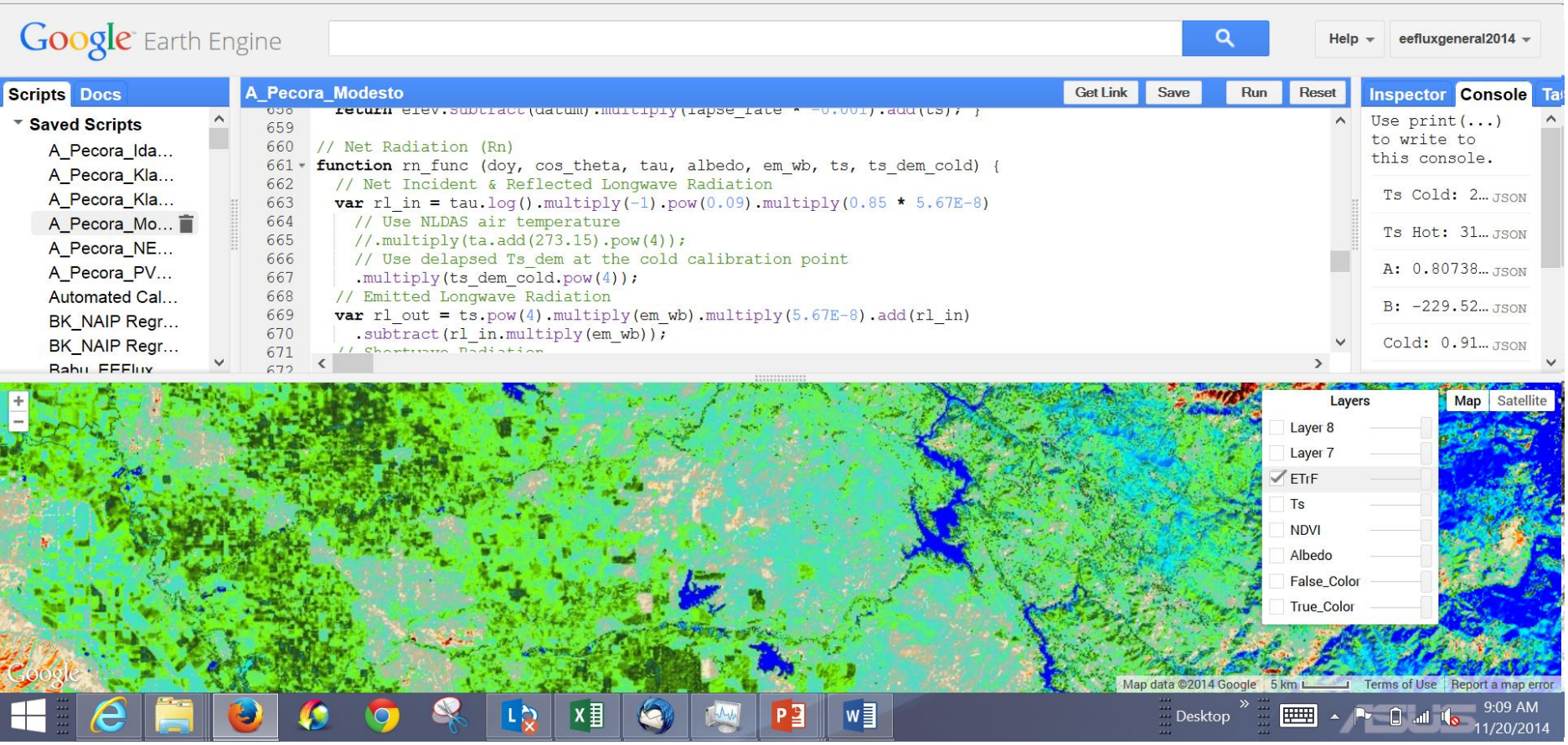
- Earth Engine Evapotranspiration Flux
- Began in 2012
- Uses the METRIC ET process (thermally-driven energy balance) as foundation
- Operates on the Google Earth Engine and Computational Cloud
- Automated operation and calibration

Why an Evapotranspiration Tool on Google Earth Engine (EE)?

- EE has enormous computing and storage power
- EE has essentially free access
- EE has strong developer support
- ET information is needed across the Global spectrum
- Google supports and encourages developers to 'change the world' regarding access to spatial information on the environment, natural resources, conservation and climate change

The Earth Engine Environment

Earth Engine JavaScript Language and Development "Playground"



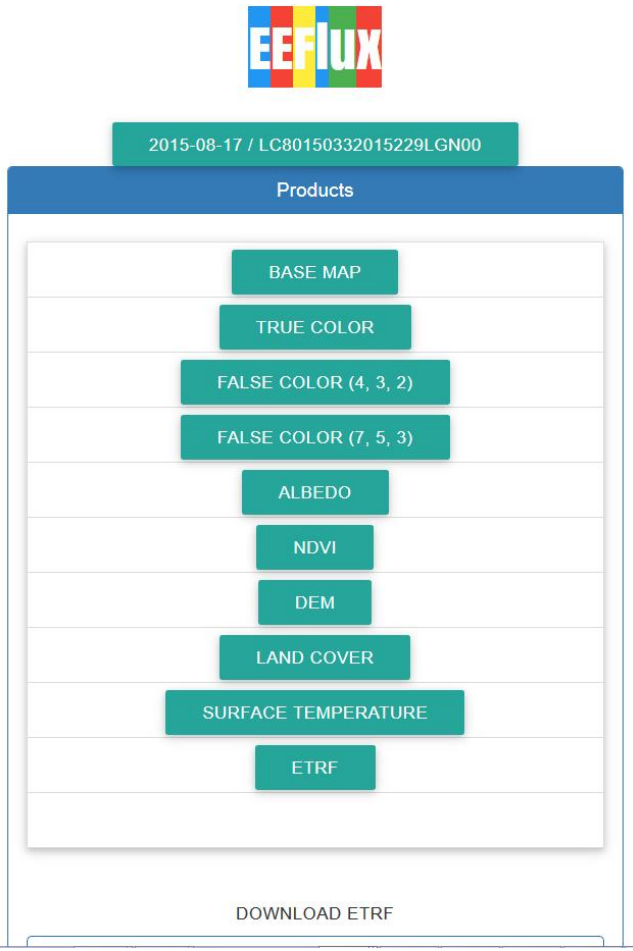
Modesto, California (Central Valley) area

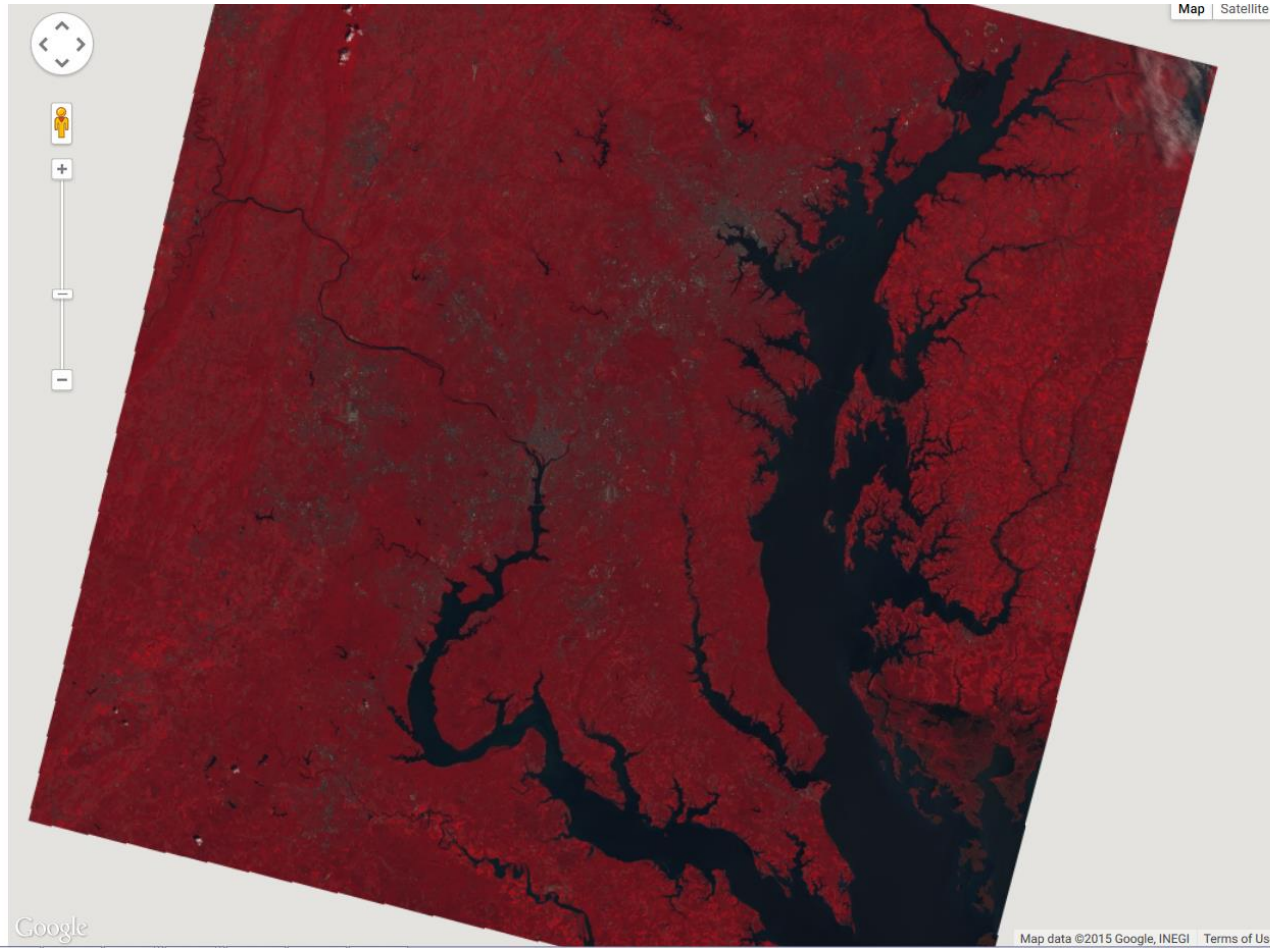
Monitoring impacts of drought

Google Earth Engine Evapotranspiration Flux - EEFlux

http://eeflux-level1.appspot.com

False Color Composite

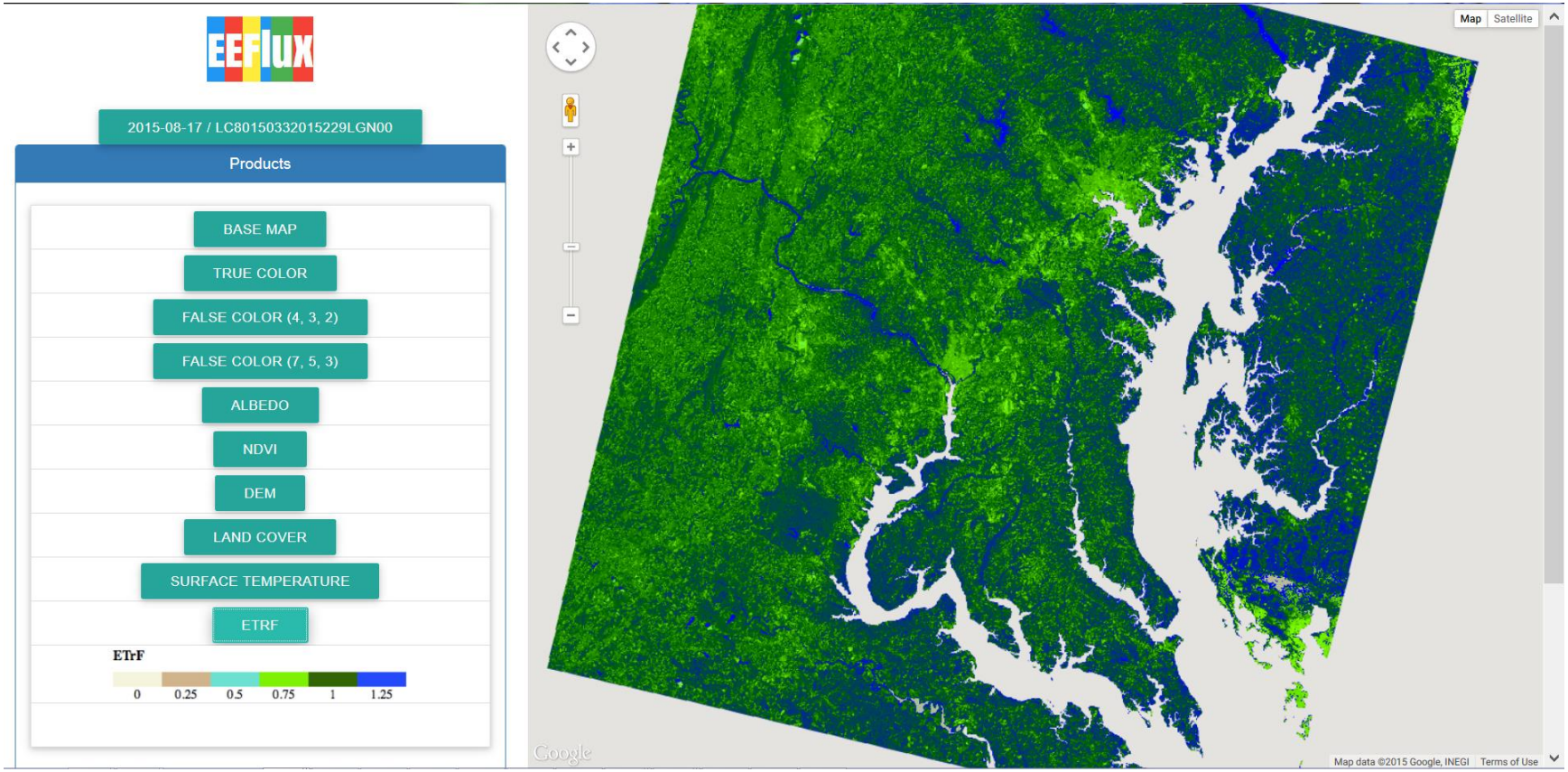




University of Nebraska Lincoln
University of Idaho
DRI Desert Research Institute
Google

Google Earth Engine Evapotranspiration Flux - EEFlux

ETrF--Fraction of Reference ET



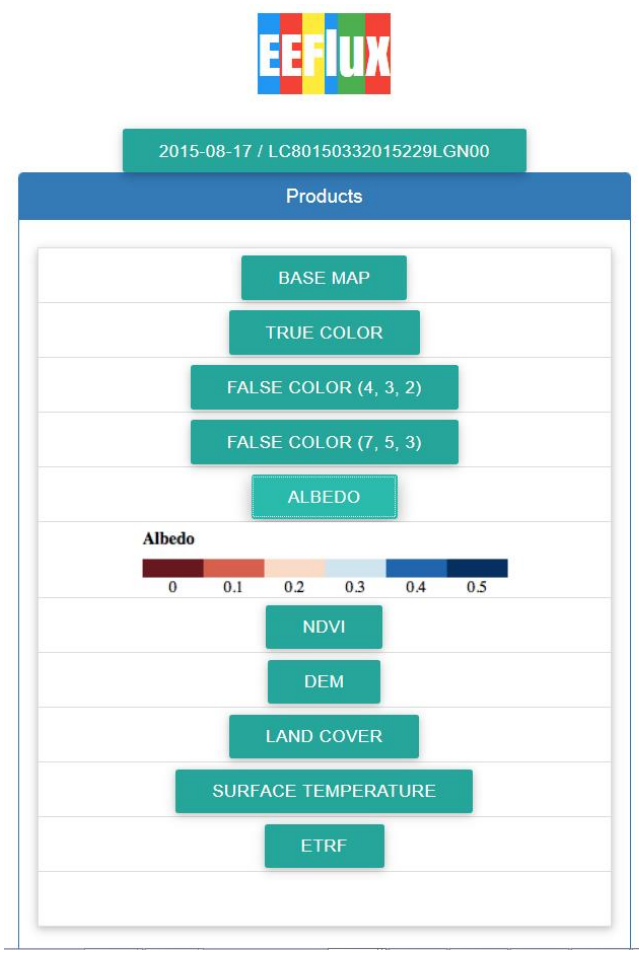
$$ET_rF = ET/ET_{ref}$$

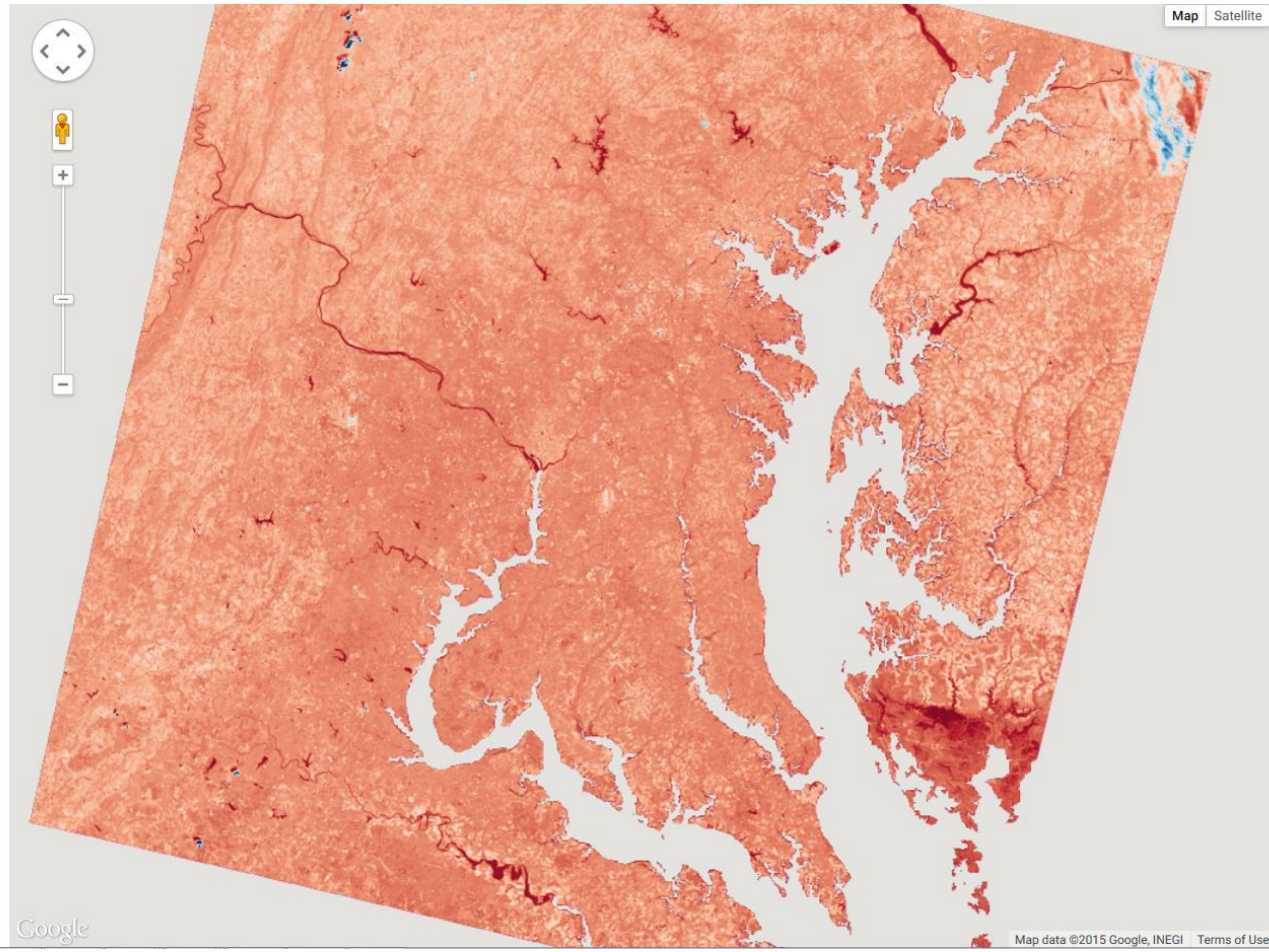
ET_{ref} is reference ET- ASCE-Penman Monteith Alfalfa reference

Google Earth Engine

Evapotranspiration Flux --- EEFlux

Albedo



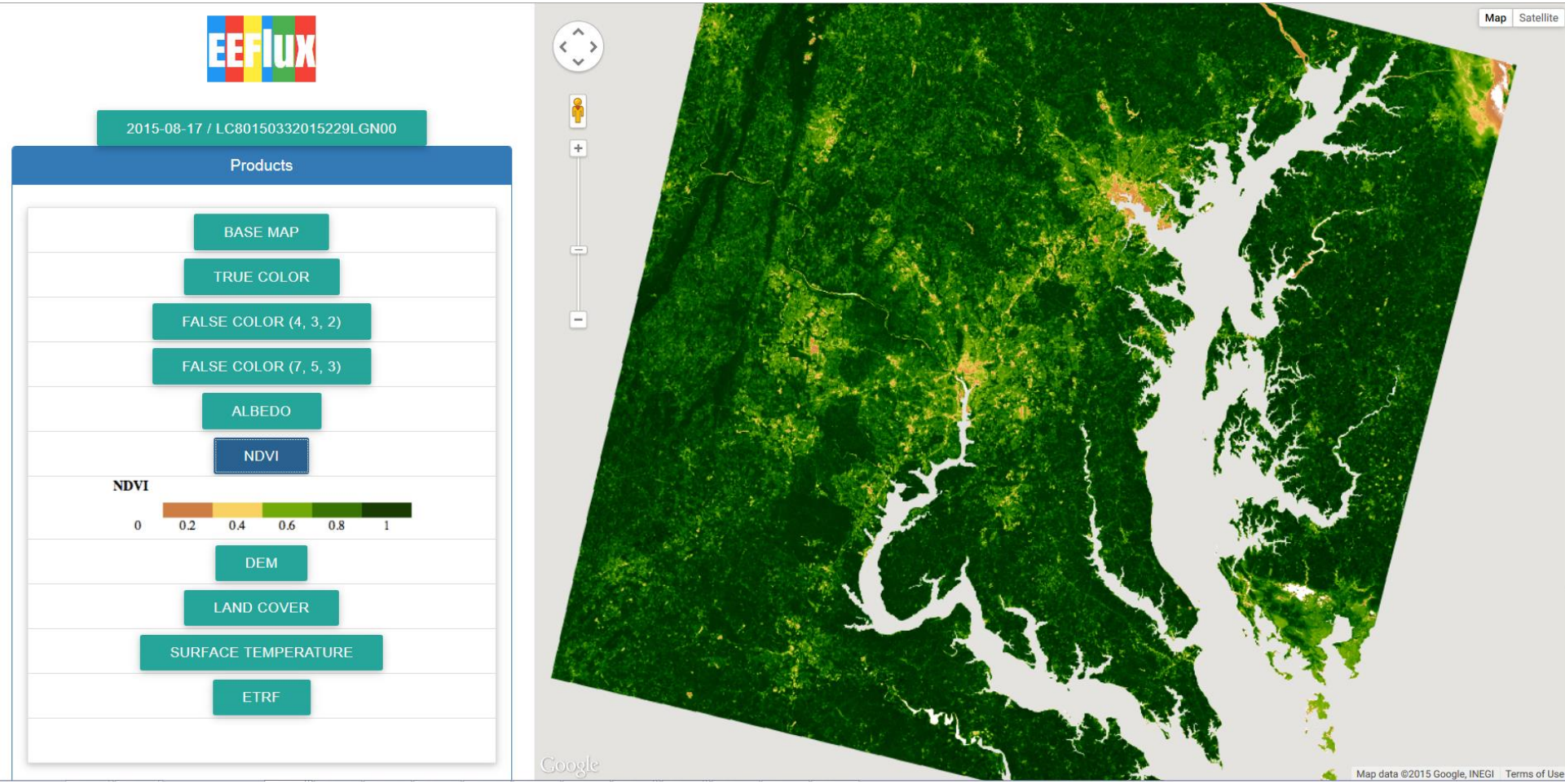


University of Nebraska Lincoln
University of Idaho
DRI Desert Research Institute
Google

Google Earth Engine

Evapotranspiration Flux --- EEFlux

NDVI--Normalized Difference Vegetation Index



University of Nebraska Lincoln

University of Idaho

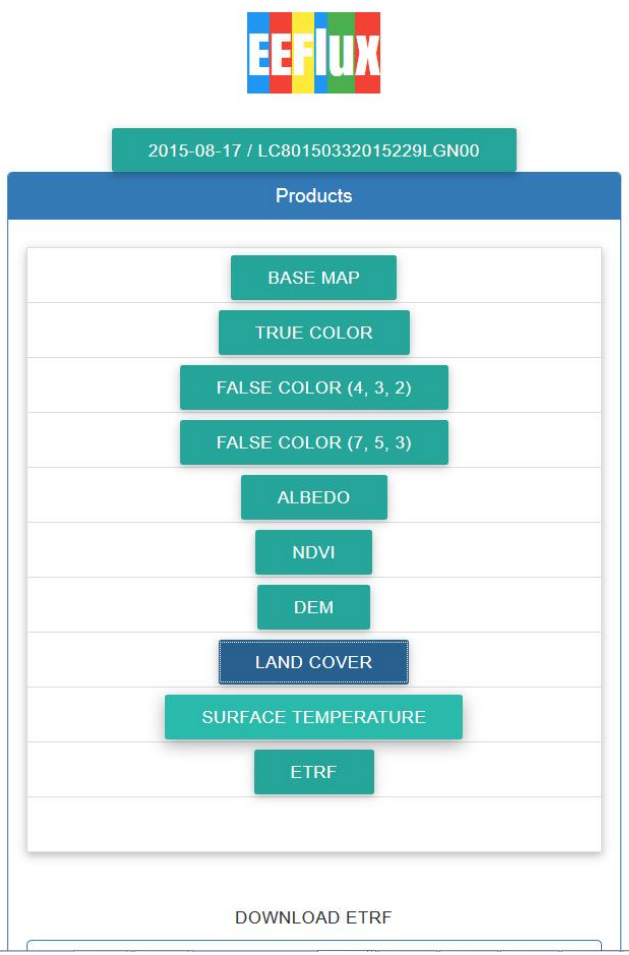
DRI Desert Research Institute

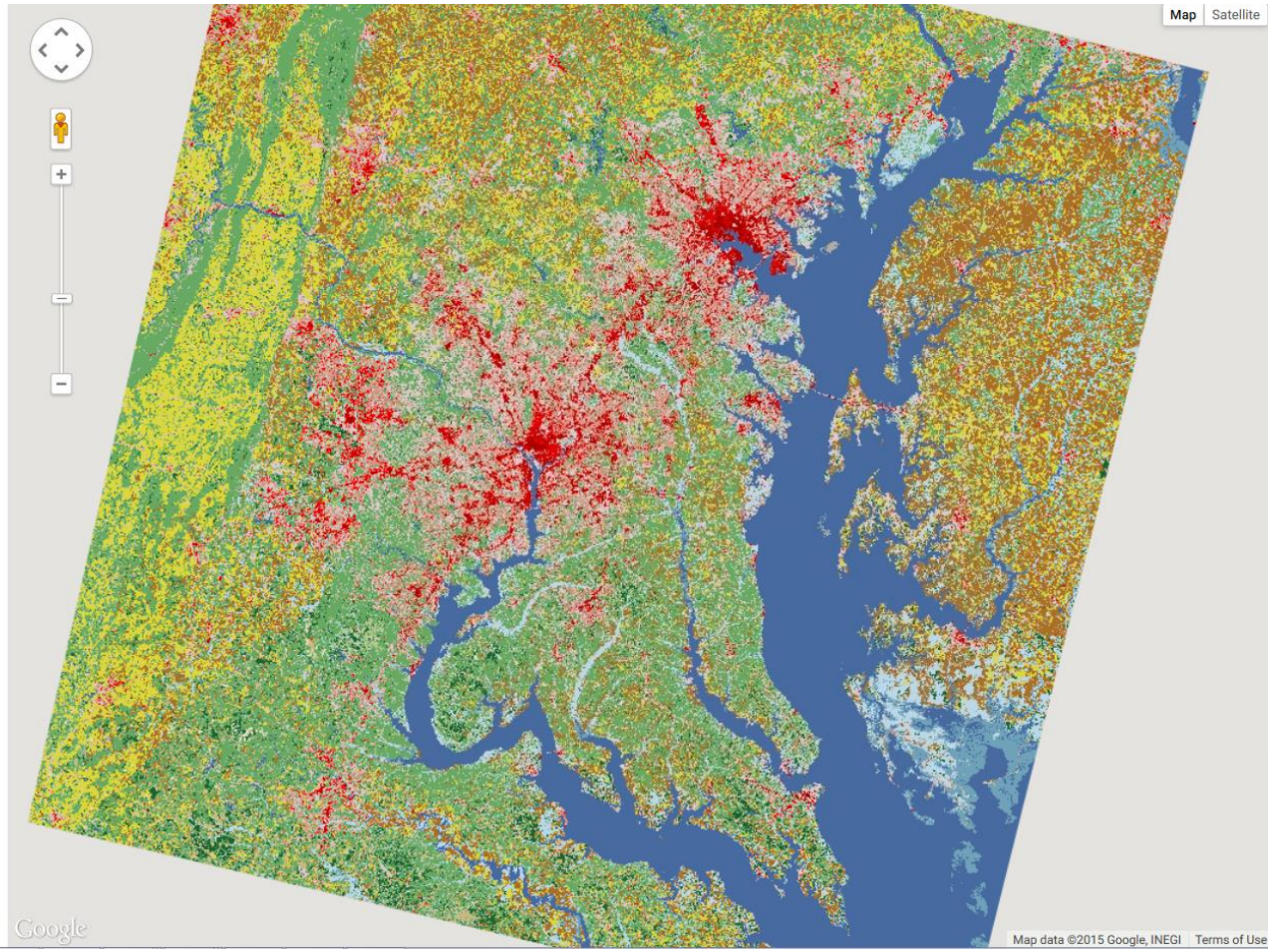
Google

Google Earth Engine

Evapotranspiration Flux --- EEFlux

NLCD - Landuse



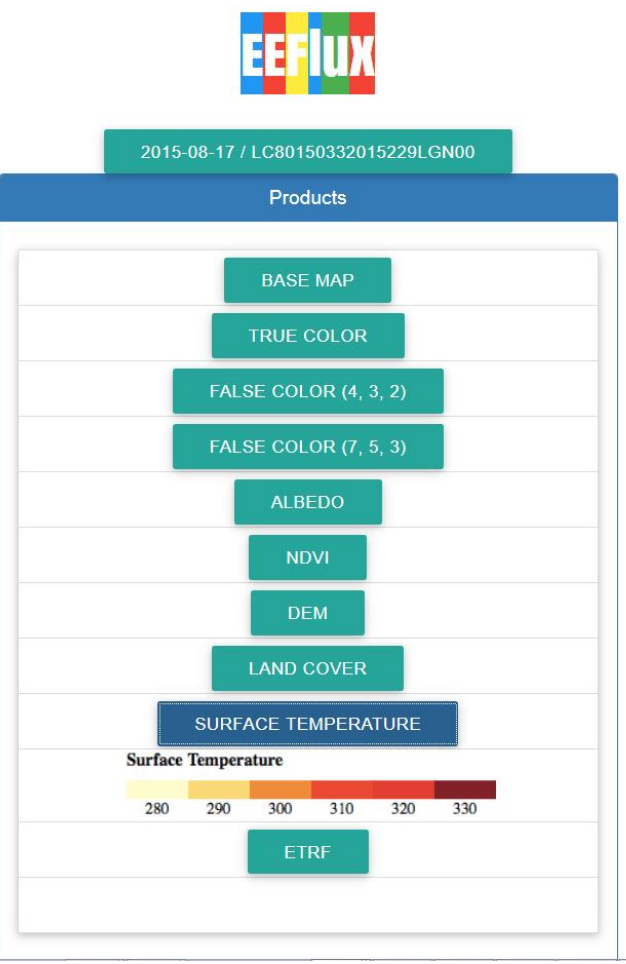


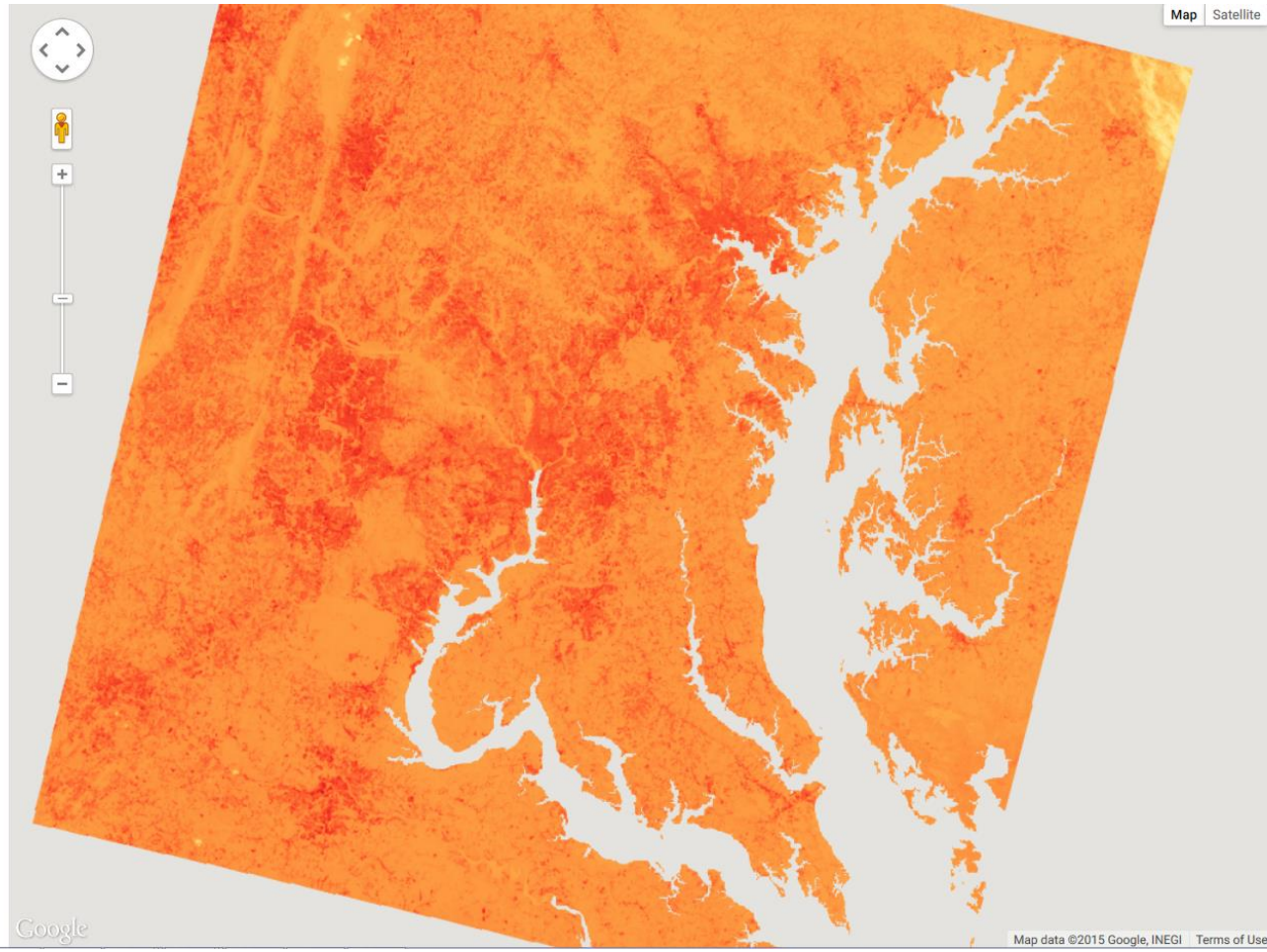
http://eeflux-level1.appspot.com

Google Earth Engine

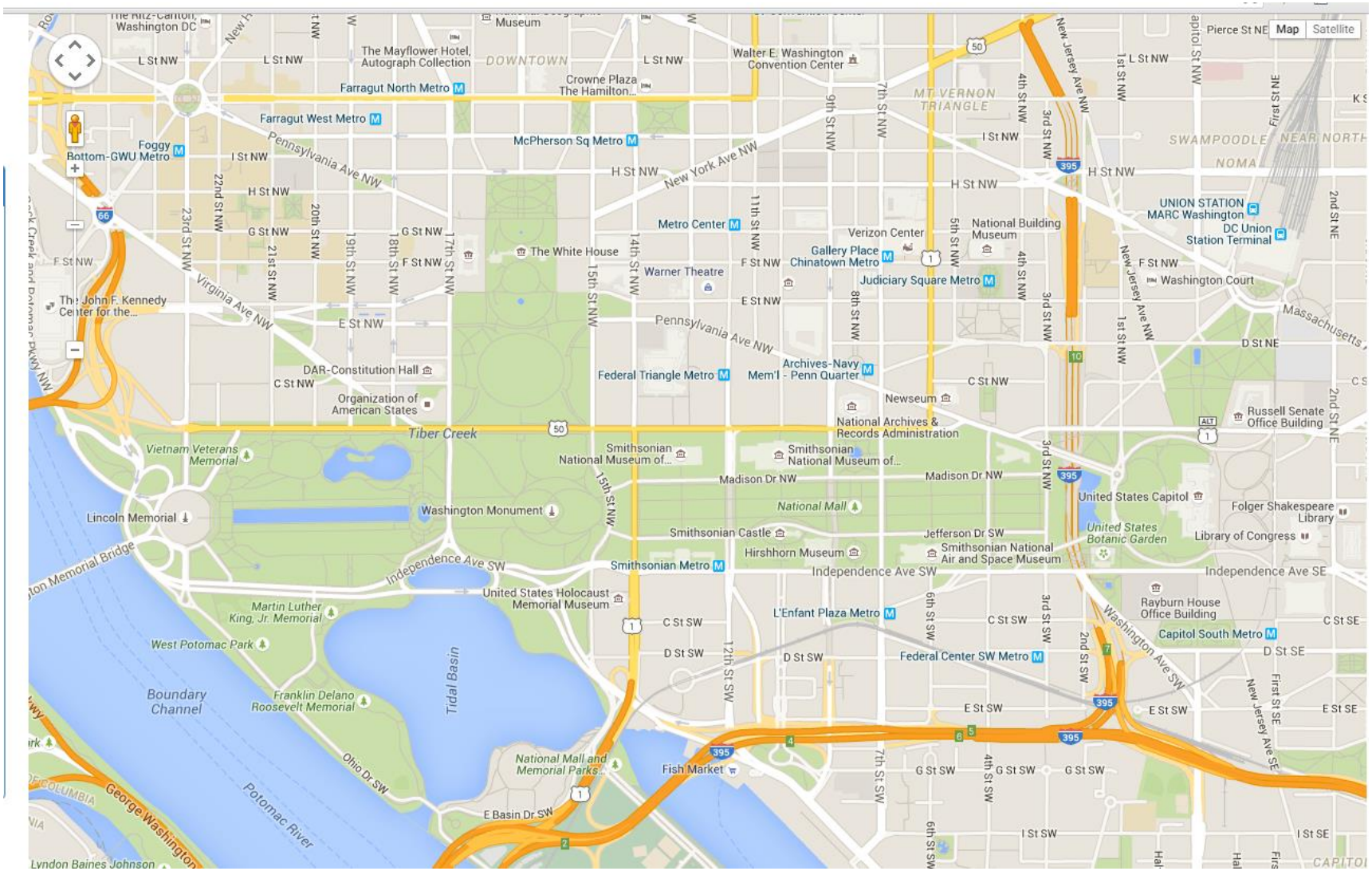
Evapotranspiration Flux --- EEFlux

Surface Temperature (K)

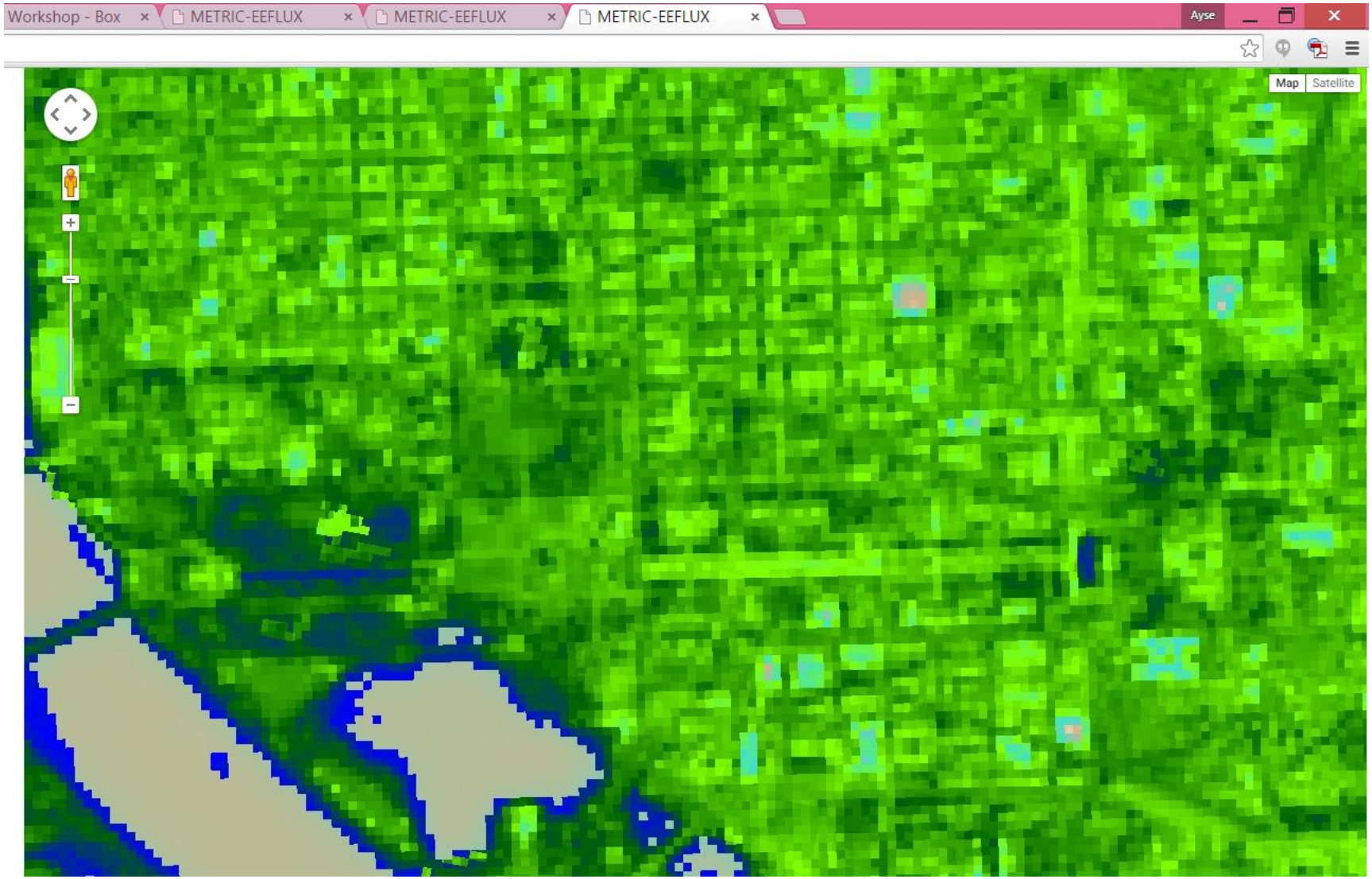




BASE MAP- NATIONAL MALL, WASHINGTON, DC
August 17, 2015

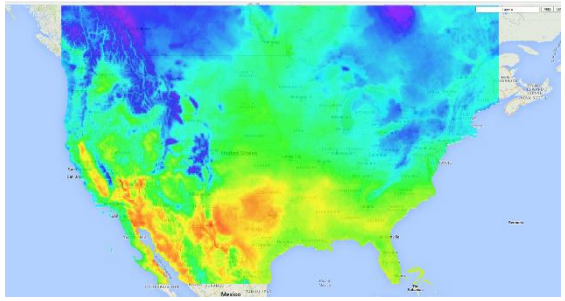


ETrF MAP- NATIONAL MALL, WASHINGTON, DC
August 17, 2015

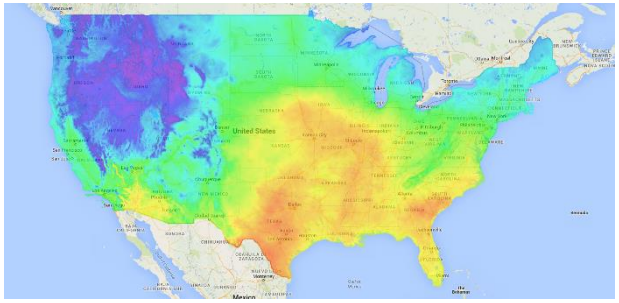


Data Resources Used by EEFlux

NLDAS-Jan 1, 1979 - Current

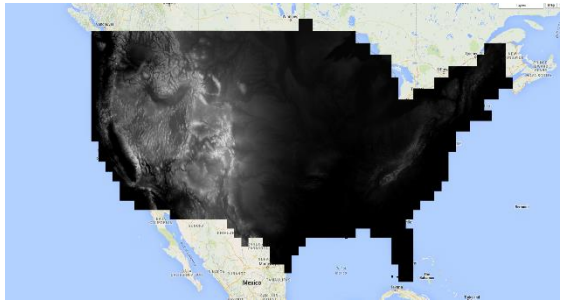


GRIDMET-Jan 1, 1979 - Current

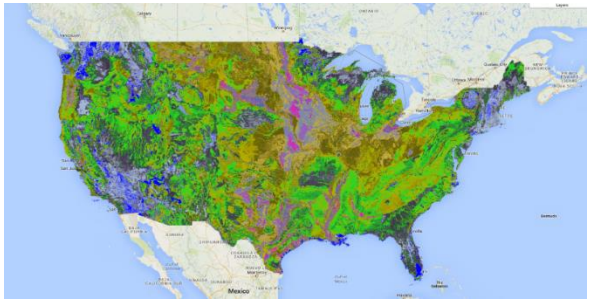


Landsat 5/7/8

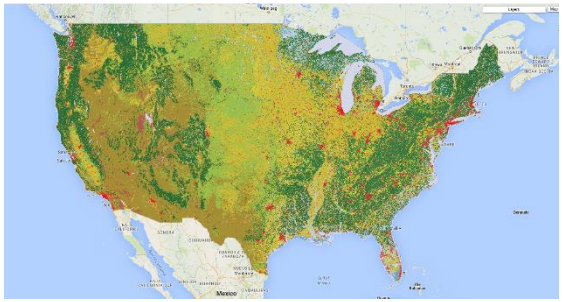
DEM



Soil Data Layers



NLCD Landuse

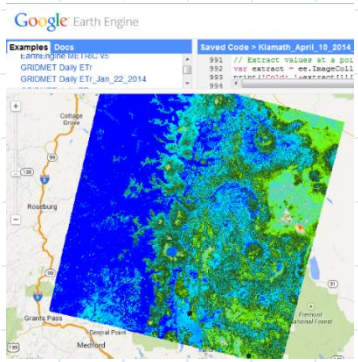


These data products are loaded and are functional on Earth Engine

http://eeflux-level1.appspot.com

Data Resources Used by EEFlux

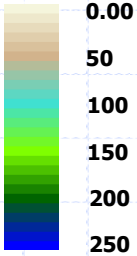
- Landsat 5/7/8 and MODIS
- Gridded Weather Data – used to calibrate EEFlux energy balance and to calculate Reference ET used for Time Integration of ET:
  - NLDAS – North American Land Data Assimilation System
    -- hourly weather data at 12 km available for > 30 year period for CONUS
  - GridMET - daily, bias corrected weather data at 4 km available for > 30 year period for CONUS
  - Climate Forecast System Version 2, 6-hourly Product (CSFV2)—nonCONUS
  - Real Time Mesoscale Analysis (RTMA) – downloaded daily to Earth Engine – used to fill in time gaps between NLDAS and today for processing recent Landsat imagery
- Soils -- Used to produce a daily time series of evaporation from bare soil.
  - Statsgo soils data is available for CONUS for top 0.15 m of soil
  - FAO soils data base & Global Soil database by Wei Shangguan et al. 2014)
- Landuse (NLCD) and Global Land Cover from European Space Agency: http://www.esa-landcover-cci.org/
- Digital Elevation Maps



Klamath, 2014

ET between Landsat dates is scaled using Reference ET

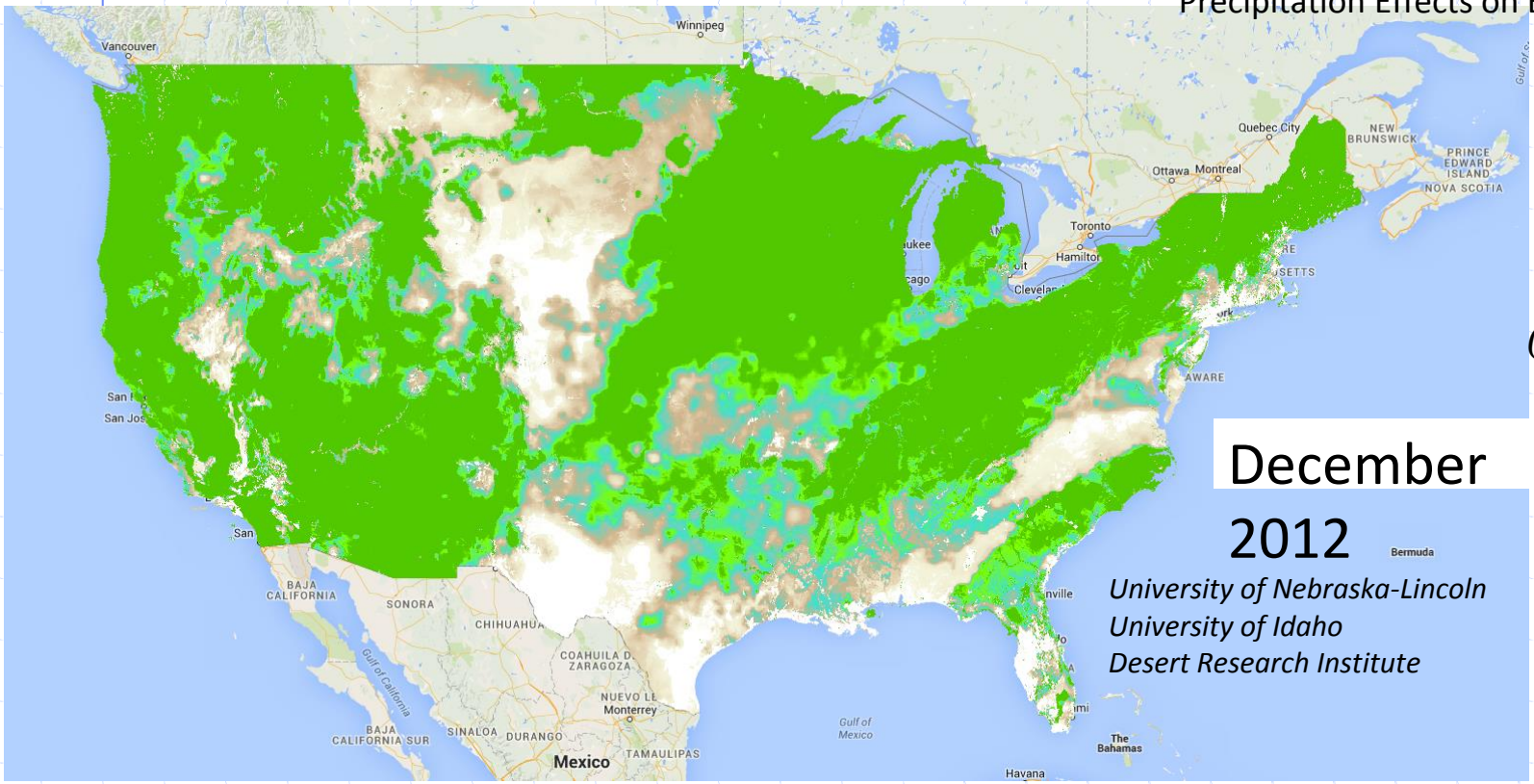
Reference ET (mm/mo)

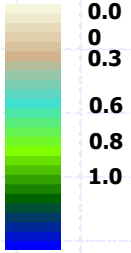


Reference ET is calculated using the ASCE Standardized Penman-Monteith Equation for the Tall Reference (Alfalfa)
--computed from the daily GridMET data set of Abatzoglou (2012)

The Soil Surface Evaporation Component of the Google Earth Engine EEFlux App.

--- **Evaporation from Bare Soil** --- used to calibrate the EEFlux Evapotranspiration Surface Energy Balance to account for background Precipitation Effects on ET Evap. Coef. (K_e)



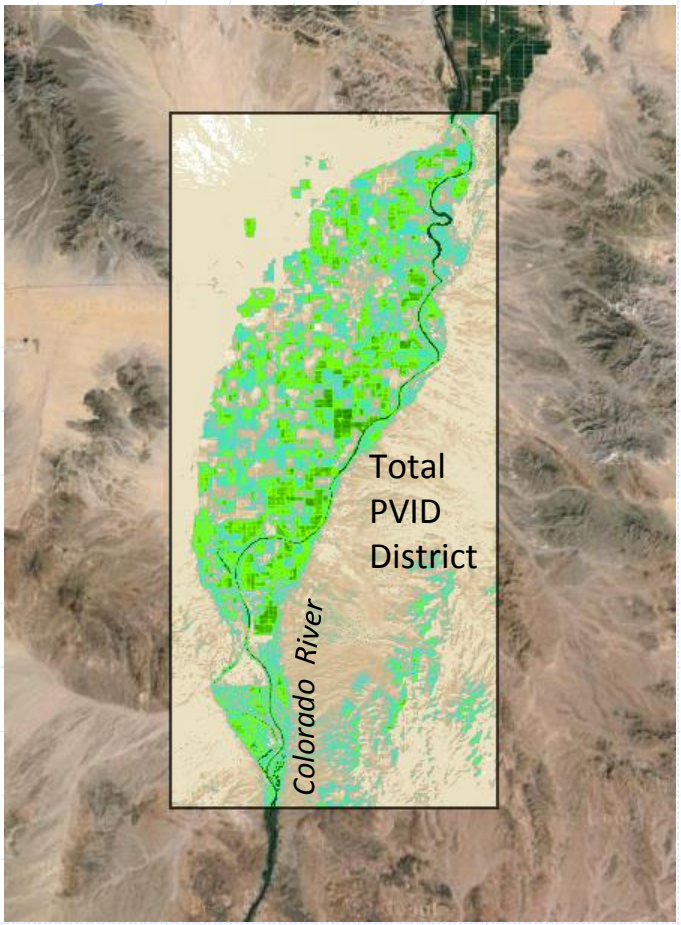


$(K_e = E_{act} / ET_{ref})$

--computed from the GridMET weather data set of Abatzoglou (2012)

-- GridMET is traceable to NLDAS and PRISM data sets

Google Earth Engine Flux --- EEFlux

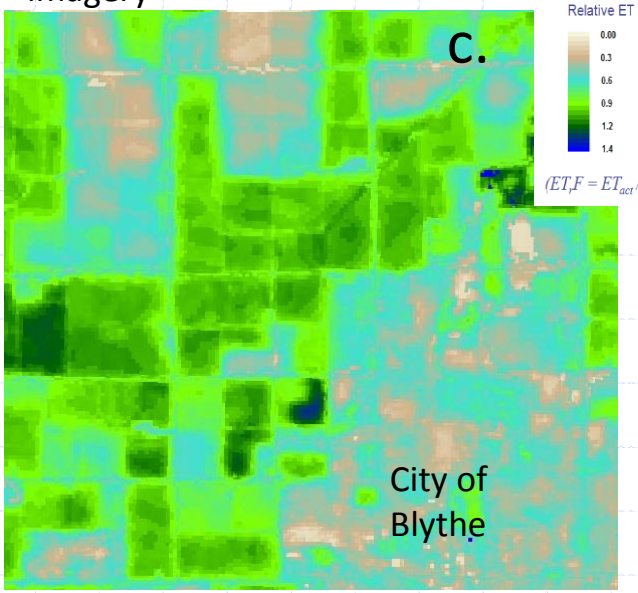


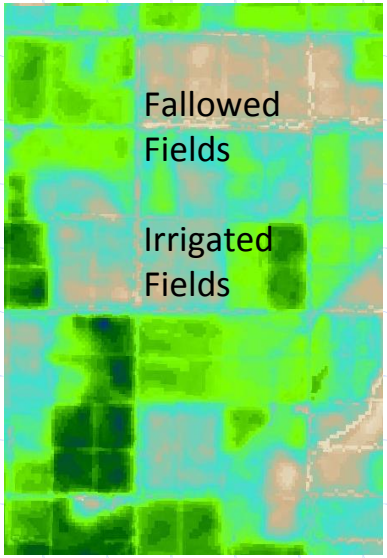
Earth Engine Evapotranspiration Flux

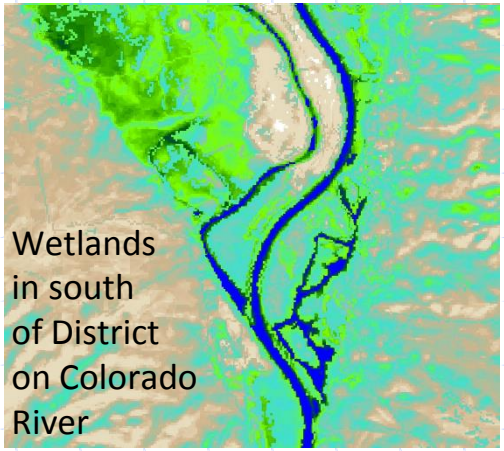
Palo Verde Irrigation District

Blythe, California – Jan. – Dec. 2008

-- Landsat 5 imagery







Univ. Nebraska-Lincoln, Univ. Idaho, Desert Research Institute

Computations are based on a complete surface energy balance *(METRIC)*

Water Literacy

- The law conservation of mass dictates that only ET is lost from the liquid water system.
- An Informed, voting public needs to be water literate
- Having free, ready access to ET information is part of that literacy

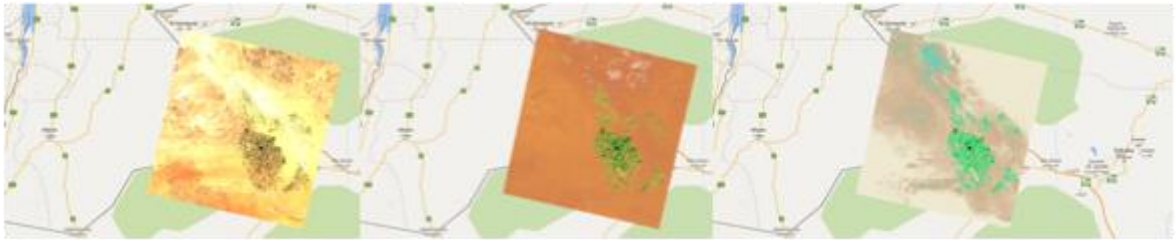
Why we have used Landsat?

- We know the importance of field scale ET maps for even the general Google community
- We recognize that water management and water rights began at the field level
- We want all Americans to have the opportunity and resources to be water literate

EEFlux Applications around the Globe

Imperial Valley and Palo Verde, CA

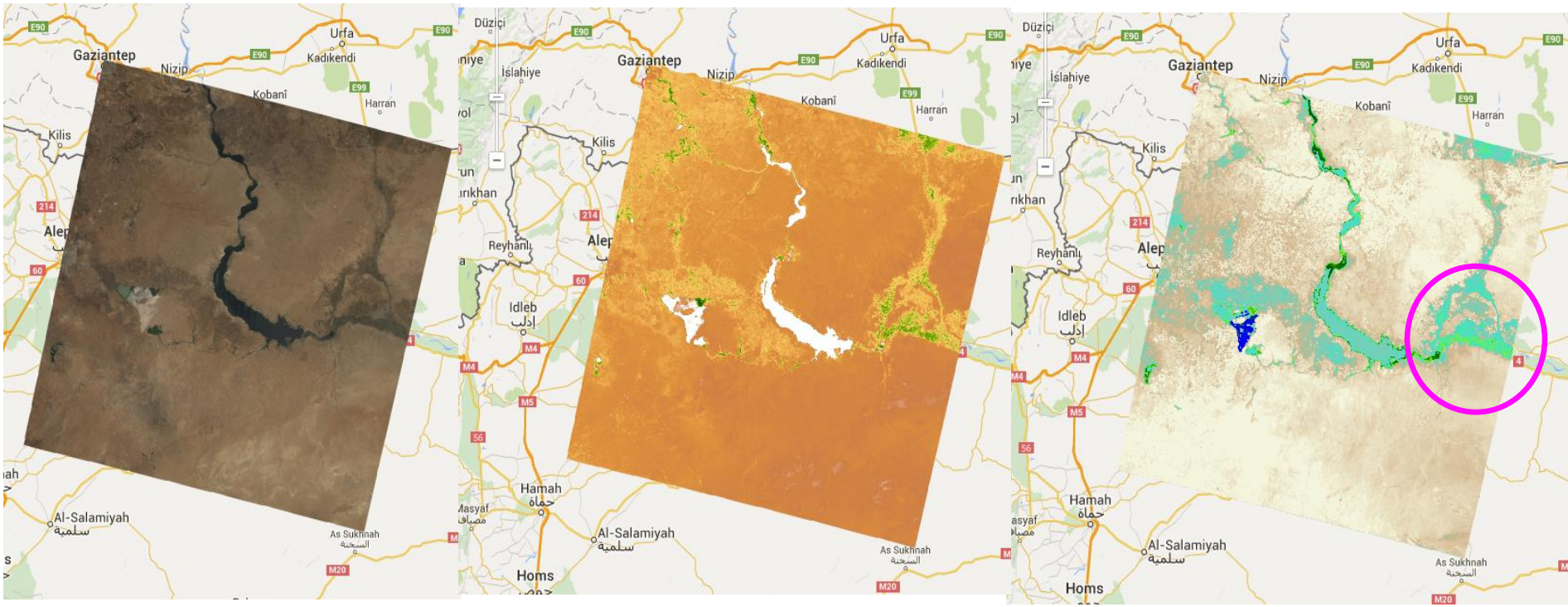
Jordan



Chile

We are testing EEFlux over the globe in a number of Countries and Conditions

EEFlux Applications around the Globe



ET (right) around the city of El Raqqah, Syria on the Euphrates River in 2015, showing reduced ET following the takeover by rebels.

2015 METRIC/EEFLUX TRAINING at UC DAVIS, CA

ORGANIZER: CALIFORNIA DEPARTMENT OF WATER RESOURCES

(27 PARTICIPANTS)

Sept 8-14, 2015

Next Steps

Automation of:

- **Advanced** Cloud detection and mitigation
- Time integration to produce monthly and annual ET volumes
- Mosaicing paths

Release of a User Console

- Permit some degree of tuning (calibration utility)
- Save project information

Level 2 EEFLux – Manual refinement of the Calibration ----Nearly ready for release. -- Will require licensing

EEFLUX

RE-RUN EEFLUX | GO BACK

This table will be populated with values sampled from the locations of the red (hot) and blue (cold) locators on the map.

Values	Hot Pixel	Cold Pixel
Latitude	0	0
Longitude	0	0
NDVI	0.16	0.87
Surface Temperature	327.75	304.98
Albedo	0.18	0.16
Land Use	82	82
Elevation	32.78	25.13

You can specify new ETrF values to use for the two locations selected for an improved calibration

ETrF hot: 0.10

ETrF cold: 1.05